CHAPTER 7. MARKUPS FOR EQUIPMENT PRICE DETERMINATION

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CHAPTER 7. MARKUPS FOR EQUIPMENT PRICE DETERMINATION

7.1   INTRODUCTION

In order to carry out the life-cycle cost (LCC) calculations described in Chapter 8, DOE needed to determine the cost to the customer of a baseline air-conditioning unit, and the cost of the more-efficient unit the customer would purchase under the standards. However, the customer price of such units is not generally known. What is known is the manufacturer's price for both baseline equipment and the more-efficient equipment. By applying a multiplier called a "markup" to the manufacturer's price, DOE can estimate the customer's price. This chapter describes how DOE derived such markups.

The equipment price to the customer will depend on how the customer purchases the equipment. The Department defines two types of distribution channels to describe how the equipment passes from the manufacturer to the customer: (1) in the first distribution channel, the manufacturer sells the equipment to a wholesaler, who in turn sells it to a mechanical contractor, who in turn sells it (and its installation) to a general contractor, who in turn sells it to the customer; (2) in the second distribution channel, the manufacturer sells the equipment directly to the customer through a national account. Figure 7.1.1 illustrates the two distribution channels for commercial air conditioners. The Department has further subdivided the first distribution channel by mechanical contractor size (as measured in annual revenues).
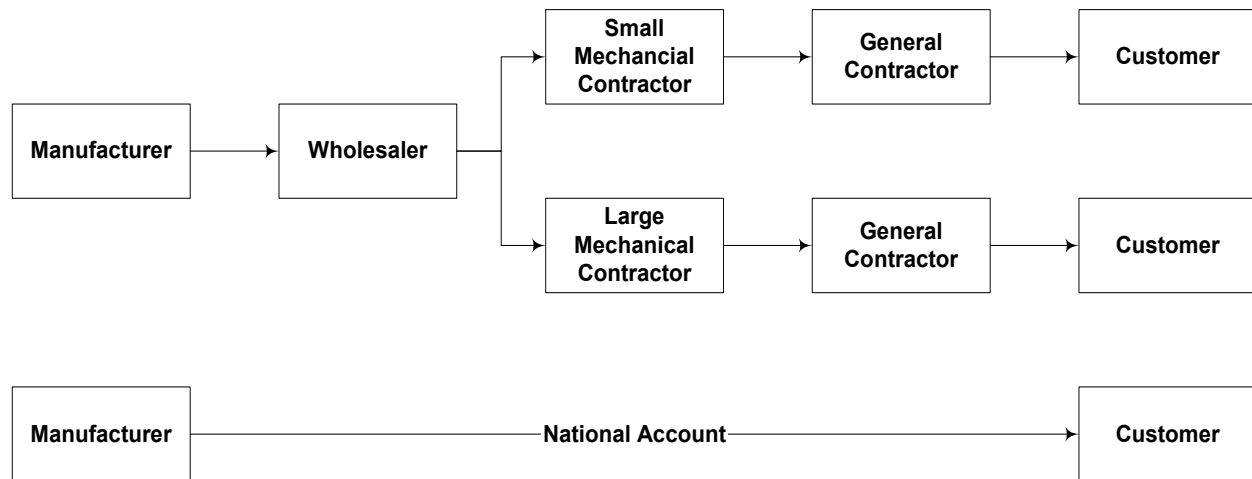
Figure 7.1.1   Distribution Channels for Commercial Air Conditioners

Based on information that equipment manufacturers provided, end-use customers purchased 50 percent of equipment through small mechanical contractors, 32.5 percent through large mechanical contractors, and the remaining 17.5 percent through national accounts. In addition, 30 percent of commercial air-conditioning equipment is purchased for the new construction market while the remaining 70 percent is assumed to serve the replacement market.

In the case of the replacement market, where equipment is purchased through a mechanical contractor, the mechanical contractor is assumed to purchase equipment directly from the wholesaler (i.e., a general contractor is not involved in the distribution of equipment for the replacement market).

The following equation describes how DOE determines the equipment price if a mechanical contractor sells the equipment to the customer:

$$EQP_{CUST} = (MFG_{BASE/STD} \cdot MU_{WHOLE} \cdot MU_{MECH\,CONT} \cdot MU_{GEN\,CONT} \cdot ST)$$

where:

EQP_{CUST}	=	equipment price to the customer ($),
$MFG_{BASE/STD}$	=	manufacturer price of baseline or standard-level equipment ($),
MU_{WHOLE}	=	wholesaler markup,
$MU_{MECH\,CONT}$	=	mechanical contractor markup,
$MU_{GEN\,CONT}$	=	general contractor markup, and
ST	=	sales tax.

The mechanical contractor markup is a function of contractor size (as measured in annual revenues) and whether the contractor serves primarily the new construction or the replacement market. The later sections of this chapter describe the determination of mechanical contractor markups as a function of contractor size and market type.

For equipment that the customer purchases directly from the manufacturer through a national account, the following equation defines the equipment price:

$$EQP_{CUST} = MFG_{BASE/STD} \cdot MU_{NATL\,ACCT} \cdot ST$$

where:

EQP_{CUST}	=	equipment price to the customer ($),
$MFG_{BASE/STD}$	=	manufacturing price of baseline or standard-level equipment ($),
$MU_{NATL\,ACCT}$	=	national account markup, and
ST	=	sales tax.

For each of the markups presented above, DOE further differentiated between a baseline markup and an incremental markup, as described below. A third type of markup, the overall markup, describes the product of all the markups within a distribution channel.

7.1.1 Baseline Markups

The Department defines baseline markups as coefficients that relate the manufacturer price of baseline equipment to the wholesale or contractor baseline sales price, as shown in the following equations:

$$EQP_{WHOLE\ BASE} = MFG_{BASE} \cdot MU_{WHOLE\ BASE}$$

$$EQP_{MECH\ CONT\ BASE} = EQP_{WHOLE\ BASE} \cdot MU_{MECH\ CONT\ BASE}$$

$$EQP_{GEN\ CONT\ BASE} = EQP_{MECH\ CONT\ BASE} \cdot MU_{GEN\ CONT\ BASE}$$

where:

MFG_{BASE}	=	manufacturer price of baseline commercial air conditioners (\$),
$MU_{WHOLE\ BASE}$	=	wholesaler markups on baseline commercial air conditioners,
$MU_{MECH\ CONT\ BASE}$	=	mechanical contractor markups on baseline commercial air conditioners,
$MU_{GEN\ CONT\ BASE}$	=	general contractor markups on baseline commercial air conditioners,
$EQP_{WHOLE\ BASE}$	=	wholesaler prices of baseline commercial air conditioners,
$EQP_{MECH\ CONT\ BASE}$	=	mechanical contractor prices of baseline commercial air conditioners, and
$EQP_{GEN\ CONT\ BASE}$	=	general contractor prices of baseline commercial air conditioners.

The use of the markups results in the wholesaler ($EQP_{WHOLE\ BASE}$), general contractor ($EQP_{GEN\ CONT\ BASE}$), and mechanical contractor ($EQP_{MECH\ CONT\ BASE}$) prices of baseline commercial air conditioners.

7.1.2   Incremental Markups

Incremental markups are coefficients that relate changes in the manufacturer price of baseline equipment to changes in the wholesaler or contractor sales price, as shown in the following equations:

$$EQP_{WHOLE\ INCR} = MFG_{INCR} \cdot MU_{WHOLE\ INCR}$$

$$EQP_{MECH\ CONT\ INCR} = EQP_{WHOLE\ INCR} \cdot MU_{MECH\ CONT\ INCR}$$

$$EQP_{GEN\ CONT\ INCR} = EQP_{MECH\ CONT\ INCR} \cdot MU_{GEN\ CONT\ INCR}$$

where:

$EQP_{WHOLE\ INCR}$	=	incremental wholesaler prices,
$EQP_{MECH\ CONT\ INCR}$	=	incremental mechanical contractor prices,
$EQP_{GEN\ CONT\ INCR}$	=	incremental general contractor prices,
MFG_{INCR}	=	change in the manufacturer price brought about by an increase in equipment efficiency due to new standards,
$MU_{WHOLE\ INCR}$	=	incremental wholesaler markups,

$MU_{MECH\ CONT\ INCR}$ = incremental mechanical contractor markups, and
$MU_{GEN\ CONT\ INCR}$ = incremental general contractor markups.

In these equations, MFG_{INCR} refers to a change in the manufacturer price (e.g., brought about by an increase in equipment efficiency due to new standards) and $MU_{WHOLE\ INCR}$, $MU_{GEN\ CONT\ INCR}$, and $MU_{MECH\ CONT\ INCR}$ refer to the incremental wholesaler, incremental general contractor, and incremental mechanical contractor markups, respectively. The use of the incremental markups results in the incremental wholesaler ($EQP_{WHOLE\ INCR}$), incremental general contractor ($EQP_{GEN\ CONT\ INCR}$), and incremental mechanical contractor ($EQP_{MECH\ CONT\ INCR}$) prices.

7.1.3 Overall Markups

Overall markups, including both overall baseline and overall incremental markups, relate the manufacturer price to the customer price as indicated by the following equations:

$$EQP_{CUST\ BASE} = MFG_{BASE} \cdot MU_{WHOLE\ BASE} \cdot MU_{MECH\ CONT\ BASE} \cdot MU_{GEN\ CONT\ BASE} \cdot ST$$
$$= MFG_{BASE} \cdot MU_{OVERALL\ BASE}$$

$$EQP_{CUST\ INCR} = MFG_{INCR} \cdot MU_{WHOLE\ INCR} \cdot MU_{MECH\ CONT\ INCR} \cdot MU_{GEN\ CONT\ INCR} \cdot ST$$
$$= MFG_{INCR} \cdot MU_{OVERALL\ INCR}$$

where:
$MU_{OVERALL\ BASE}$ = baseline overall markup that is the product of all the other baseline markups,
$MU_{OVERALL\ INCR}$ = incremental overall markup that is the product of all the other incremental markups,
$EQP_{CUST\ BASE}$ = baseline customer price, and
$EQP_{CUST\ INCR}$ = incremental customer price.

The use of the baseline overall and incremental overall markups results in the baseline customer price ($EQP_{CUST\ BASE}$) and the incremental customer price ($EQP_{CUST\ INCR}$). For a particular standard level that increases manufacturer price, the total equipment price to the customer is simply the sum of the baseline customer price ($EQP_{CUST\ BASE}$) and the incremental customer price ($EQP_{CUST\ INCR}$).

7.2 BASIC ASSUMPTIONS USED TO ESTIMATE WHOLESALER AND CONTRACTOR MARKUPS

The Department derived the wholesaler and contractor markups from three key assumptions about commercial air-conditioner costs. It based the wholesaler and mechanical contractor markups on firm balance sheet data, while it based the general contractor markups on U.S. Census data for the commercial and institutional building construction industry. The Department obtained the firm balance sheets from the trade associations representing

wholesalers[1] and mechanical contractors.[2] It put the U.S. Census building construction data used for developing general contractor markups into the same form as the balance sheet data for wholesalers and mechanical contractors.[3] These balance sheets break out the components of all costs incurred by firms that supply and install air conditioners.[a] The key assumptions used to estimate markups using these financial data are:

- The firm balance sheets faithfully represent the various average costs incurred by firms distributing and installing commercial air-conditioning.

- These costs can be divided into two categories: (1) costs that vary in proportion to the manufacturer price of commercial air conditioners (variable costs); and (2) costs that do not vary with the manufacturer price of commercial air conditioners (fixed costs).

- Commercial air conditioner wholesaler and contractor prices vary in proportion to commercial air conditioner wholesaler and contractor costs included in the balance sheets.

In support of the first assumption, the balance sheets itemize firm costs into a number of expense categories, including direct costs to purchase or install the equipment, operating labor and occupancy costs, and other operating costs and profit. Although wholesalers and contractors tend to handle multiple commodity lines, including air conditioners, furnaces, and boilers, the data provide the most accurate available indication of commercial air-conditioner expenses.

Information obtained from the trade literature and selected heating, ventilating, and air-conditioning (HVAC) wholesalers, contractors, and consultants tends to support the second assumption. This information indicates that wholesale and contractor markups vary according to the quantity of labor and materials used to distribute and install appliances, with markups on labor tending to be much larger than markups on materials.[b,4] The obtained information describes markups as varying much more in relation to sales volume than in relation to other factors, including appliance efficiency. This last finding strongly suggests that labor inputs vary more with sales volume than with appliance cost or efficiency. In the following discussion, the Department assumes a division of costs between those that do not scale with the manufacturer price (labor and occupancy expenses), and those that do (operating expenses and profit). This division of costs leads to the estimate of wholesaler and contractor markups described below.

In support of the third assumption, the HVAC wholesaler and contractor industry is extremely competitive and consumer demand for commercial air-conditioning is inelastic, i.e.,

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[a] Wholesalers and mechanical contractors to which these reports refer handle multiple commodity lines, including residential and commercial air-conditioning and warm-air furnaces.

[b] One HVAC spokesman advocates pricing according to the amount of labor and material inputs, based on the concept of Dual Overhead Accounting. Stated markups for mechanical contractors were 15 percent on equipment and materials and 200-300 percent on labor.

the demand is not expected to decrease significantly with an increase in price. The large number of HVAC firms listed in the 1997 Census indicates the competitive nature of the market. For example, there are more than 5,500 HVAC wholesalers,[5] more than 37,000 general contractors,[6] and 84,000 HVAC contractors[7] listed in the 1997 Census. Following standard economic theory, competitive firms facing inelastic demand either set prices in line with costs or quickly go out of business.[8]

7.3   ESTIMATION OF WHOLESALE MARKUPS

Wholesalers reported median data in a confidential survey that the Air-Conditioning & Refrigeration Wholesalers Association (ARW) conducted of 37 member firms.[1] In the survey, ARW itemized revenues and costs into cost categories, including direct equipment expenses (cost of goods sold), labor expenses, occupancy expenses, other operating expenses, and profit. The Department presents these data in full in Appendix K; Table 7.3.1 summarizes them as cost per dollar revenue in the first data column. For example, the direct equipment expenses (cost of goods sold) represent about $0.74 per dollar sales revenue; in other words, for every $1 wholesalers take in as sales revenue, they use $0.74 to pay the direct equipment costs. Labor expenses represent $0.15 per dollar sales revenue, occupancy expenses represent $0.04, other operating expenses represent $0.06, and profit accounts for $0.03 per dollar sales revenue.

Table 7.3.1   Wholesale Expenses and Markups

	Wholesale Firm Expenses or Revenue	
Description	**Per Dollar Sales Revenue***	**Per Dollar Cost of Goods**
Direct Cost of Equipment Sales: Cost of goods sold	$0.74	$1.00
Labor Expenses: Salaries, Payroll, Benefit plans	$0.15	$0.20
Occupancy Expenses: Rent, Utilities	$0.04	$0.05
Other Operating Expenses: Insurance, Depreciation	$0.06	$0.07
Profit	$0.03	$0.04
Baseline Markup ($MU_{WHOLE\ BASE}$): Revenue per dollar cost of goods		1.36
Incremental Markup ($MU_{WHOLE\ INCR}$): Increased revenue per dollar increase cost of goods sold		1.11

* Values do not add up to $1.00 due to independent rounding.

Source: ARW, *Wholesaler Profit Survey Report*, 1998. See Appendix K for complete breakdown of costs.

The second data column of Table 7.3.1 shows the data converted from costs per dollar revenue into revenue per dollar cost of goods sold. The Department accomplished this conversion by dividing each cost category in the first data column of Table 7.3.1 by $0.74 (i.e., equipment expenditure per dollar revenue). The data in column two show that, for every $1.00 the wholesaler spends on equipment costs, the wholesaler earns $1.00 in sales revenue to cover the equipment cost, $0.20 to cover labor costs, $0.05 to cover occupancy expenses, $0.07 for other operating expenses, and $0.04 in profits. This totals to $1.36 in sales revenue earned for

every $1.00 spent on equipment costs. Therefore, the wholesale baseline markup ($MU_{WHOLE\ BASE}$) is 1.36, since the wholesaler earns $1.36 in sales revenue for every $1.00 spent to purchase the equipment.

The Department also used the data in column two to estimate the incremental markups. The incremental markup will depend upon which of the costs in Table 7.3.1 are variable and which are fixed. For example, for a $1.00 increase in the manufacturer equipment price, if all of the other costs scale with the manufacturer price (i.e., all costs are variable), the increase in wholesaler price will be $1.36, implying that the incremental markup is 1.36, or the same as the baseline markup. At the other extreme, if none of the other costs is variable, then a $1.00 increase in the manufacturer price will lead to a $1.00 increase in the wholesaler price, for an incremental markup of 1.0. Actually, DOE believes that the labor and occupancy costs will be fixed and that the other operating costs and profit will scale with the manufacturer price (i.e., be variable). In this case, for a $1.00 increase in the manufacturer price, the wholesaler price will increase by $1.11, giving a wholesale incremental markup (MU_{WHOLE_INCR}) of 1.11.

7.3.1   Estimation of Wholesale Markup Probability Distribution

The Department characterized the markups developed from the above financial data with probability distributions through a statistical analysis of U.S. Census data for wholesalers.[9] The statistical analysis provided a standard deviation on the markups of wholesaler firms in the U.S. The Department then applied the standard deviation to the single-point baseline and incremental markups calculated above to create normal probability distributions for these markups.

Based on the analysis of U.S. Census data for wholesalers, DOE calculated a standard deviation of 8.2 percent for the baseline markup. Appendix K describes this calculation. The Department assumed that the variation determined for the baseline markup applied to the incremental markup as well. For the baseline markup of 1.36, a standard deviation of 8.2 percent translates into an absolute value of 0.112. For the incremental markup of 1.11, a standard deviation of 8.2 percent translates into an absolute value of 0.091.

Figures 7.3.1 and 7.3.2 show the probability distributions that DOE used to characterize the wholesale baseline and incremental markups. Note that for the incremental markup, the standard deviation of 0.091 results in markup values that are less than 1.0. Since a markup value of less than 1.0 would not allow the wholesaler to recover its costs, DOE truncated all values less than 1.0 from the normal distribution. To retain the same mean value of 1.11, DOE truncated an equal percentage of markup values from the high end of the normal distribution as well.
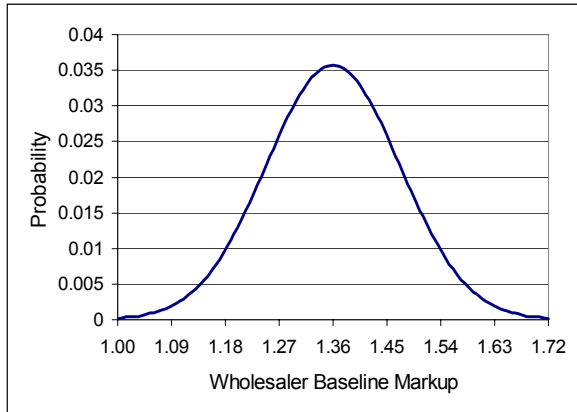
Figure 7.3.1   **Wholesaler Baseline Markup**
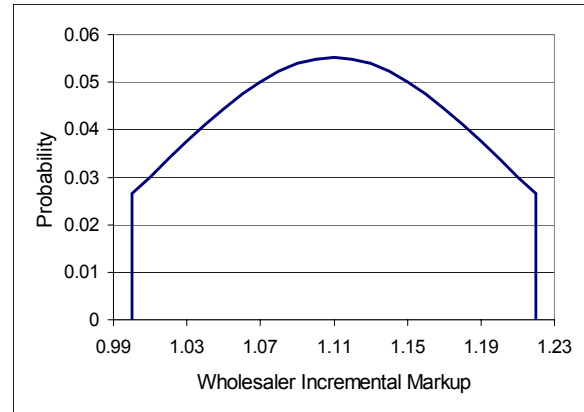   **Probability Distribution**

Figure 7.3.2   **Wholesaler Incremental Markup**
                              Probability Distribution

7.4   ESTIMATION OF MECHANICAL CONTRACTOR MARKUPS

The HVAC contractors, defined here as mechanical contractors, reported median cost data in an Air Conditioning Contractors of America (ACCA) financial analysis of the HVAC industry.[2] Data reported in that analysis are similar to the itemized revenues and costs reported by wholesalers, including expenses broken out by direct cost of equipment sales, payroll expense, occupancy expense, other operating expense, and profit categories. For convenience, the first data column in Table 7.4.1 summarizes these expenses as expenses per dollar sales revenue (Appendix K contains the full set of data). The only important difference is that the direct cost of equipment sales in this table includes out-of-pocket installation costs as well as the cost of goods sold. As shown in the table, the direct cost of sales represents about $0.65 per dollar sales revenue to the contractor. Labor expenses represent $0.15 per dollar sales revenue, occupancy expenses represent $0.01 per dollar sales revenue, other operating expenses are $0.14 per dollar sales revenue, and profit is $0.05 per dollar sales revenue. Interestingly, the contractor expenditures per dollar sales revenue in Table 7.4.1 are quite similar to the wholesaler expenditures per dollar sales revenue reported earlier.

Table 7.4.1   Mechanical Contractor Expenses and Markups

	Contractor Expenses or Revenue	
Description	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs
Direct Cost of Equipment Sales: Cost of goods sold; Installation cost	$0.65	**$1.00**
Labor Expenses: Salaries, Payroll, Benefit plans	$0.15	**$0.23**
Occupancy Expenses: Rental and other occupancy costs	$0.01	**$0.02**
Other Operating Expenses: Advertising, Depreciation, Insurance	$0.14	**$0.21**
Operating Profit and Other Income: Profit, Other income	$0.05	**$0.07**
Baseline Markup ($MU_{MECH\ CONT\ BASE}$): Contractor revenue per dollar		**1.53**
Incremental Markup ($MU_{MECH\ CONT\ INCR}$): Increased revenue per dollar increase direct cost of sales		**1.28**

Source: ACCA, *Financial analysis for the HVACR Contracting Industry, 1995 Edition*, 1995. See Appendix K for complete breakdown of costs.

The Department converted these expenses per dollar sales into revenue per dollar cost of goods sold by dividing each figure in the first data column by $0.65. For every $1.00 the mechanical contractor spends on equipment costs, the mechanical contractor earns $1.00 in sales revenue to cover the equipment cost, $0.23 to cover labor costs, $0.02 to cover occupancy expenses, $0.21 for other operating expenses, and $0.07 in profits. This totals to $1.53 in sales revenue earned for every $1.00 spent on equipment costs. This tells us that the mechanical contractor baseline markup ($MU_{MECH\ CONT\ BASE}$) is 1.53, since the contractor earns $1.53 in sales revenue for every $1.00 spent to purchase the equipment.

As with the wholesaler data in the previous section, DOE can use the data in column two in the table above to estimate the incremental markups. The incremental markup will depend on which of the costs in Table 7.4.1 are variable and which are fixed. At one extreme, if all of the other costs scale with the equipment price (i.e., all costs are variable), the increase in mechanical contractor price will be $1.53, implying that the incremental markup is 1.53, or the same as the baseline markup. At the other extreme, if none of the other costs is variable, then a $1.00 increase in the equipment price will lead to a $1.00 increase in the mechanical contractor price, for an incremental markup of 1.0. The Department expects the labor and occupancy costs to be fixed and the other operating costs and profit to scale with the equipment price (i.e., be variable). In this case, for a $1.00 increase in the equipment price, the mechanical contractor price will increase by $1.28, giving a mechanical contractor incremental markup ($MU_{MECH\ CONT\ INCR}$) of 1.28.

7.4.1   Markups for Small and Large Mechanical Contractors in the Replacement and New Construction Markets

The baseline and incremental markups derived above for mechanical contractors are average values for all contractors, both small and large, and across both the replacement and new construction markets. This section describes how DOE further disaggregated these markups into those pertaining to small versus large contractors (as measured by annual revenues), and further

disaggregated each of these contractor types into the replacement and the new construction market. The goal was to calculate baseline and incremental markups separately for the following four categories: (1) small contractors in the replacement market; (2) small contractors in the new construction market; (3) large contractors in the replacement market; and (4) large contractors in the new construction market. The ACCA financial data provide contractor gross margin data as a function of contractor size and market type. Since the gross margin is the sum of all contractor labor and operating expenses plus profit, the gross margin allows for the determination of a baseline markup. Although the financial data allow for the determination of disaggregated markups, the data are not disaggregated in such a way as to allow for the calculation of baseline markups separately for each of the above four categories of contractors (i.e., small/replacement, small/new, large/replacement, and large/new). The data do allow for the development of contractor markups as a function of contractor size and by contractor type. Thus (as will be discussed below), DOE developed a process to further disaggregate the markups into each of the above four contractor categories.

Table 7.4.2 summarizes the gross margin and resulting baseline markup data for contractors as a function of contractor size. The table presents data for contracting businesses earning annual revenues in each of the four following categories: (1) below one million dollars; (2) from one to two million dollars; (3) from two to five million dollars; and (4) over five million dollars. The Department aggregated the data into two categories: contractors earning annual revenue above two million dollars and contractors earning annual revenue below two million dollars. This aggregation was accomplished through the use of data on the total annual value of business done by HVAC contractors.[10]

Table 7.4.2   Mechanical Contractor Expenses and Markups by Contractor Size

Description	Less than $1M		$1M to $2M		$2M to $5M		Greater than $5M	
	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs
Direct Cost of Equipment Sales:* Cost of goods sold; Installation cost	$0.60	$1.00	$0.61	$1.00	$0.64	$1.00	$0.68	$1.00
Gross Margin: Operating and Labor Expenses plus profit	$0.40	$0.66	$0.39	$0.63	$0.36	$0.56	$0.32	$0.48
Baseline Markup ($MU_{MECH\ CONT\ BASE}$): Contractor revenue per dollar direct cost of sales		1.66		1.63		1.56		1.48
Dollar Value of Business Done	$19,098,557		$15,227,328[†]		$12,740,950[‡]		$40,576,202	
	Contractor Revenue: Less than $2M				**Contractor Rev.: Greater than $2M**			
Aggregated Baseline Markup ($MU_{MECH\ CONT\ BASE}$)	1.65				1.50			

* Direct cost of equipment sales determined by subtracting the gross margin from $1.00.

[†] Gross margin data are provided for contractors with revenues between $1 to $2 million. Revenue data from the U.S. Census Bureau are actually for contractors with revenues between $1 to $2.5 million.

[‡] Gross margin data are provided for contractors with revenues between $2 to $5 million. Revenue data from the U.S. Census Bureau are actually for contractors with revenues between $2.5 to $5 million.

Source for Gross Margin: ACCA, *Financial analysis for the HVACR Contracting Industry, 1995 Edition*, 1995.

Table 7.4.3 summarizes the gross margin and resulting baseline markup data for contractors as a function of market type. The table presents data for contracting businesses serving the residential and light commercial market.

Table 7.4.3   Mechanical Contractor Expenses and Markups by Market Type

Description	Contractor Expenses or Revenue by Market Type					
	All Residential and Light Commercial		**New Construction Resid. and Light Comm.**		**Replacement Resid. and Light Comm.**	
	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs	Per Dollar Sales Revenue	Per Dollar of Direct Sale Costs
Direct Cost of Equipment Sales:* Cost of goods sold; Installation cost	$0.64	$1.00	$0.71	$1.00	$0.62	$1.00
Gross Margin: Operating and Labor Expenses plus profit	$0.36	$0.57	$0.29	$0.41	$0.38	$0.62
Baseline Markup ($MU_{MECH\ CONT\ BASE}$): Contractor revenue per dollar direct cost of sales		1.57		1.41		1.62

* Direct cost of equipment sales determined by subtracting the gross margin from $1.00.

Source for Gross Margin: ACCA, *Financial analysis for the HVACR Contracting Industry, 1995 Edition*, 1995.

The aggregation of the primary data did not allow for the calculation of the baseline markups separately for each of the four categories (small/replacement, small/new, large/replacement, and large/new). Therefore, DOE took the following approach to disaggregate the small and large contractor markups presented in Table 7.4.2 into separate values for the replacement and new construction markets for each contractor type. Using the data in Table 7.4.3, which is for all sizes of contractors, DOE calculated that the markup for the replacement market is 3.2 percent higher than the markup across all market types, and the markup for the new construction market is 10.2 percent lower than the markup across all market types. The Department assumed that these same percentage differences would apply between the small/replacement and small/new categories, and between the large/replacement and large/new categories.   In other words, DOE assumed that the markup for small contractors in the replacement market would be 3.2 percent higher than the markup for small contractors across all markets, and the markup for small contractors in the new market would be 10.2 percent lower than the markup for small contractors across all markets. Likewise, DOE assumed that the markup for large contractors in the replacement market would be 3.2 percent higher than the markup for such contractors across all markets, and the markup for large contractors in the new market would be 10.2 percent lower than the markup for such contractors across all markets.

This procedure gives estimates for the small and large new construction baseline markups of 1.48 and 1.35, respectively, and estimates for the small and large replacement baseline markups of 1.70 and 1.55, respectively (Table 7.4.4).

Table 7.4.4   Baseline Markups by Mechanical Contractor Size and Market Type

Market Type	Residential and Light Commercial		Small Contractors	Large Contractors
	Baseline Markup	Percent Difference with New & Replacement	Baseline Markup	Baseline Markup
All	1.57	-	1.65	1.50
New Construction	1.41	10.3%	1.48*	1.35*
Replacement	1.62	3.1%	1.70†	1.55†

* Estimated based on 10.3 percent difference between new construction and all residential and light commercial contractors.

† Estimated based on 3.1 percent difference between replacement and all residential and light commercial contractors.

In order to calculate the incremental large and small mechanical contractor markups for each market type, DOE needed to be able to separate the variable from the fixed costs for each contractor type in each market type. However, the data are only divided into direct costs and gross margin for each of these categories. The direct costs are a variable cost, but the gross margin includes labor costs, which are fixed, and non-labor costs, which are variable. The Department used the data in Table 7.5.1 to divide the gross margin into labor and non-labor components. From Table 7.5.1, the average gross margin (which is the sum of all labor and operating expenses plus profit) for all contractor types in all market types is $0.35. The non-labor component of gross margin is the sum of the other operating expenses plus profit ($0.14 + $0.05), which is $0.19. The non-labor (variable) component of gross margin is thus 53 percent of the total gross margin. The Department assumed for each of the four sub-categories that the non-labor component of the total gross margin was also 53 percent. Following this assumption, DOE estimated the small new and small replacement incremental markups to be 1.26 and 1.36, respectively. Similarly, DOE estimated the large new and large replacement incremental markups to be 1.18 and 1.29, respectively (Table 7.4.5).

Table 7.4.5   Incremental Markups by Mechanical Contractor Size and Market Type

Description	Small New Construction		Small Replacement		Large New Construction		Large Replacement	
Baseline Markup ($MU_{MECH\ CONT\ BASE}$)	1.48		1.70		1.35		1.55	
	Per Dollar Sales Revenue	Per Dollar of Direct Sales Cost	Per Dollar Sales Revenue	Per Dollar of Direct Sales Cost	Per Dollar Sales Revenue	Per Dollar of Direct Sales Cost	Per Dollar Sales Revenue	Per Dollar of Direct Sales Cost
Direct Cost of Equipment Sales (per dollar sales revenue)	$0.68*	$1.00	$0.59*	$1.00	$0.74*	$1.00	$0.65*	$1.00
Gross Margin (per dollar sales revenue)	$0.32	$0.48	$0.41	$0.70	$0.26	$0.35	$0.35	$0.55
Non-Labor percent of Gross Margin	53%		53%		53%		53%	
Non-Labor (per dollar sales revenue)	$0.17	$0.26	$0.22	$0.37	$0.14	$0.18	$0.19	$0.29
Incremental Markup ($MU_{MECH\ CONT\ INCR}$)	1.26		1.37		1.18		1.29	

* Determined from Baseline Markup ($1 / MU_{MECH\ CONT\ BASE}$)

7.4.2   Estimation of Mechanical Contractor Markup Probability Distribution

The Department characterized the markups developed from the ACCA financial data with probability distributions through a statistical analysis of U.S. Census data for plumbing, heating, and air-conditioning contractors.[10] The statistical analysis provided a standard deviation on the markups of mechanical contractors in the U.S. The Department then applied the standard deviation to the single-point baseline and incremental markups calculated above to create normal probability distributions for these markups.

The Department calculated a standard deviation of 3.0 percent for the contractor markups. Figures 7.4.1 and 7.4.2 show the probability distributions that DOE used to characterize the mechanical contractor baseline and incremental markups for large contractors in the new construction market. The probability distributions for the three other sets of contractor markups have similar shapes. Appendix K details the analysis to determine the standard deviation of baseline mechanical contractor markups.
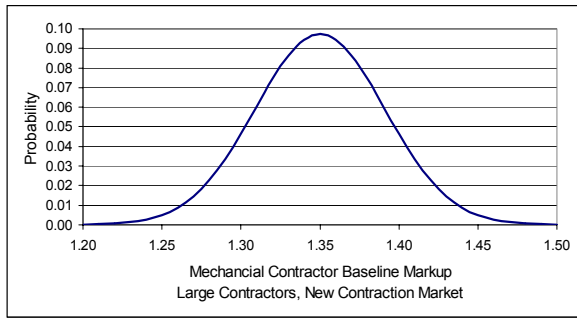
Mechancial Contractor Baseline Markup
Large Contractors, New Contraction Market

Mechancial Contractor Baseline Markup
Large Contractors, New Contraction Market

Figure 7.4.1   Mechanical Contractor Baseline Markup Probability Distribution, Large Contractors, New Construction Market
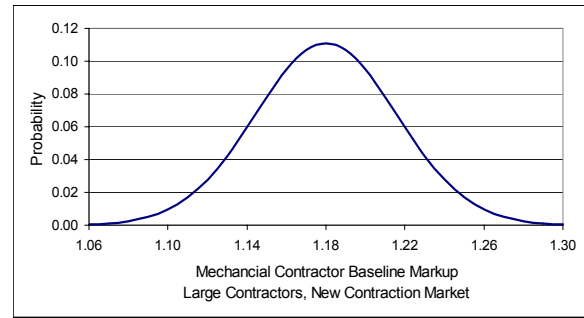
Figure 7.4.2   Mechanical Contractor Incremental Markup Probability Distribution, Large Contractors, New Construction Market

7.5   ESTIMATION OF GENERAL CONTRACTOR MARKUPS

The Department derived markups for general contractors from U.S. Census Bureau data for the commercial and institutional building construction sector.[11] This sector includes establishments primarily engaged in construction work, including new construction work, additions, alterations, and repairs. The U.S. Census Bureau data for the construction sector include detailed statistics for establishments with payrolls, similar to the data reported by ARW for wholesalers and, as will be discussed in the next section, ACCA for mechanical contractors. The primary difference is that the U.S. Census Bureau reports itemized revenues and expenses for the construction industry as a whole in total dollars rather than in typical values for an average or representative business. Because of this, DOE assumed that the total dollar values that the U.S. Census Bureau reported, once converted to a percentage basis, represented revenues and expenses for an average or typical contracting business. As with the data for wholesalers, Table 7.5.1 summarizes the expenses for general contractors as expenses per dollar sales revenue, in the first data column (Appendix K contains the full set of data). For example, the direct cost of sales represents about $0.81 per dollar sales revenue to the general contractor. Labor expenses represent $0.07 per dollar sales revenue, occupancy expenses represent $0.01 per dollar sales revenue, other operating expenses represent $0.01, and profit makes up $0.10 per dollar sales revenue.

Table 7.5.1   General Contractor Expenses and Markups

Description	Contractor Expenses or Revenue	
	Per Dollar Sales Revenue *	**Per Dollar of Direct Sale Costs**
Direct Cost of Equipment Sales: Cost of goods sold; Installation cost	$0.81	**$1.00**
Labor Expenses: Salaries, Payroll, Benefit plans	$0.07	$0.09
Occupancy Expenses: Rental and other occupancy costs	$0.01	$0.01
Other Operating Expenses: Advertising, Depreciation, Insurance	$0.01	**$0.01**
Operating Profit and Other Income: Profit, Other income	$0.10	**$0.12**
Baseline Markup ($MU_{GEN\,CONT\,BASE}$): Contractor revenue per dollar		1.24
Incremental Markup ($MU_{GEN\,CONT\,INCR}$): Increased revenue per dollar increase direct cost of sales		**1.13**

* Values do not add up to $1.00 due to independent rounding.

Source: Commercial and Institutional Building Construction, 1997 Economic Census, EC97C-2333B, U.S. Department of Commerce, January 2000, Table 4 (Detailed Statistics for Establishments with Payroll: 1997). See Appendix K for complete breakdown of costs.

The Department converted these expenses per dollar sales into revenue per dollar cost of goods sold, by dividing each figure in the first data column by $0.81. The data in column two show that, for every $1.00 the general contractor spends on equipment costs, the general contractor earns $1.00 in sales revenue to cover the equipment cost, $0.09 to cover labor costs, $0.01 to cover occupancy expenses, $0.01 for other operating expenses, and $0.12 in profits. This totals to $1.24 in sales revenue earned for every $1.00 spent on equipment costs. This tells us that the general contractor baseline markup ($MU_{GEN\,CONT\,BASE}$) is 1.24, since the general contractor earns $1.24 in sales revenue for every $1.00 spent to purchase the equipment.

As in the previous sections, DOE can also use the data in column two in the table above to estimate the incremental markups. The incremental markup will depend on which of the costs in Table 7.4.1 are variable and which are fixed. At one extreme, if all of the other costs scale with the equipment price (i.e., all costs are variable), the increase in general contractor price will be $1.24, implying that the incremental markup is 1.24, or the same as the baseline markup. At the other extreme, if none of the other costs are variable, then a $1.00 increase in the equipment price will lead to a $1.00 increase in the general contractor price, for an incremental markup of 1.0. The Department believes the labor and occupancy costs to be fixed and the other operating costs and profit to scale with the equipment price (i.e., be variable). In this case, for a $1.00 increase in the equipment price, the general contractor price will increase by $1.13, giving a general contractor incremental markup ($MU_{GEN\,CONT\,INCR}$) of 1.13.

7.5.1   Estimation of General Contractor Markup Probability Distribution

The Department characterized the markups developed from the above financial data with probability distributions through a statistical analysis of the same U.S. Census data for the general contracting industry.[12] Appendix K details the analysis to determine the standard

deviation of markups. The statistical analysis provided a standard deviation on the markups of general contracting firms in the U.S. The Department then applied the standard deviation to the single-point baseline and incremental markups above to create normal probability distributions for these markups.

The Department calculated a standard deviation of 3.9 percent for the baseline markup. It assumed the variation determined for the baseline markup applied to the incremental markup as well. For the baseline markup of 1.24, a standard deviation of 3.9 percent translates into an absolute value of 0.048. For the incremental markup of 1.13, a standard deviation of 3.9 percent translates into an absolute value of 0.044.

Figures 7.5.1 and 7.5.2 show the probability distributions that DOE used to characterize the general contractor baseline and incremental markups.
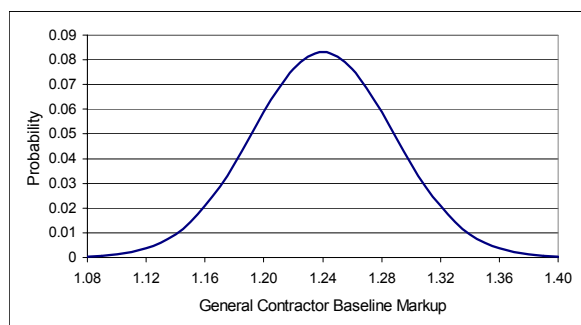

Figure 7.5.1   General Contractor Baseline Markup Probability Distribution
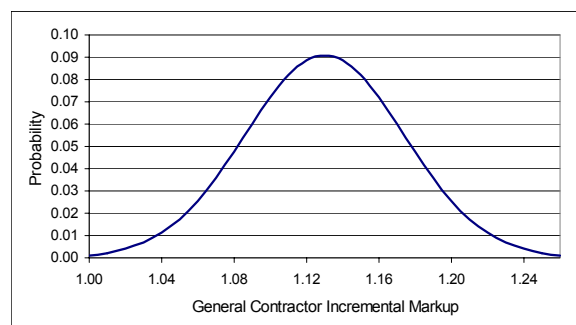
Figure 7.5.2   General Contractor Incremental Markup Probability Distribution

7.6   SALES TAX

The sales tax represents State and local sales taxes that are applied to the customer price of the equipment. The sales tax is as a multiplicative factor that increases the customer equipment price.

The Department derived sales taxes representative of both State and local sales taxes from 1997 States sales tax data[13] and 1997 local sales tax data.[14] Using State unitary air-conditioner shipment data from 1994,[15] DOE weighted the State and local sales tax data by the percentage of unitary air conditioners shipped to each State, to derive a probability distribution of sales taxes. The sales tax data were than aggregated into one-percentage-point bins (i.e., sales taxes from 5 to 5.99 percent, sales taxes from 6 to 6.99 percent).

The distribution of sales tax rates ranges from a minimum of zero percent to a maximum of 10 percent with a mean value of 6.7 percent. The Department applied sales taxes to the customer equipment price irrespective of the distribution channel and the market in which the

customer is located. Table 7.6.1 provides the distribution of sales tax rates based on the percentage of unitary air-conditioner shipments in each sales tax bin.

Table 7.6.1   Distribution of Sales Tax Rates

	Sales Tax Rate					
	0%	**5%**	**6%**	**7%**	**8%**	**10%**
Probability of Rate	1%	10%	29%	37%	22%	1%

7.7   NATIONAL ACCOUNTS

Equipment purchased through national accounts is an exception to the usual distribution of HVAC equipment to end-users. Large customers of HVAC equipment use national accounts to circumvent the typical chain of distribution, thereby allowing them to negotiate equipment prices directly with the manufacturer. Due to the large volume of equipment purchased, large customers, such as national retail chains, are able to purchase equipment directly from the manufacturer at significantly lower prices than could be obtained through the typical distribution chain.

In order to capture the price savings realized from equipment purchased through national accounts, DOE derived a "national account" markup, assuming that the resulting equipment price increase was one-half of that realized from a typical chain of distribution. In other words, if the price increase resulting from the product of the wholesale, mechanical contractor, and general contractor markups is $100, the "national account" markup is such that the price increase is one-half of that, or $50. The Department based the use of a "national account" markup that is one-half of that realized from a typical chain of distribution on the assumption that the resulting "national account" equipment price must fall somewhere between the manufacturer price (i.e., a markup of 1.0) and the customer price under a typical chain of distribution. Because DOE did not know typical values for the actual "national account" equipment price, it chose a value of one-half.

To illustrate the development of the "national account" markup further, this section provides the following example of how DOE derived it. Using a baseline manufacturer price of $2098 for 7.5-ton air conditioners and baseline wholesaler, general contractor, and mechanical contractor markups of 1.36, 1.24, and 1.53, respectively, the resulting baseline customer equipment price without sales taxes is $5413 ($2098 •1.36 • 1.24 • 1.53). (Note that the mechanical contractor baseline markup is an average value representing all contractors irrespective of size and market served.) The dollar value increase due to the above distribution channel markups is $3315 ($5413 - $2098). Under the assumption that national account customers realize equipment price increases equal to one-half of that due to a typical channel of distribution, the dollar value of the equipment price increase under the national account is $1658 (one-half of $3315). The resulting equipment price is $3756 ($1658 + $2098), which results in a deduced "national account" markup of 1.79 percent ($3756 ÷ $2098).

7.8 OVERALL MARKUPS

The Department multiplied the wholesale and contractor markups described above by the sales tax to obtain the overall baseline and incremental markups shown in Tables 7.8.1 and 7.8.2, respectively. It based overall markups on one of three assumed distribution channels as well as whether the equipment is being purchased for the new construction or replacement market. The Department based the distribution channel on whether equipment is purchased through: (1) small mechanical contractors; (2) large mechanical contractors; or (3) national accounts. Thus, Tables 7.8.1 and 7.8.2 present six overall markups each for both the overall baseline and incremental markups. In addition, the tables show a weighted-average overall markup assuming that (1) the new construction and replacement markets represent 30 percent and 70 percent of the market, respectively, and (2) end-use customers purchase 50 percent of equipment through small mechanical contractors, 32.5 percent through large mechanical contractors, and the remaining 17.5 percent through national accounts. The weighted-average overall baseline markup equals 2.31, while the weighted-average overall incremental markup equals 1.56.

The Department used the overall markup to estimate the customer price of baseline equipment, given the manufacturer cost of baseline equipment. For example, if the manufacture price of a baseline commercial air conditioner is $100, DOE can multiply this by the weighted-average overall baseline markup to estimate that the baseline customer price of the commercial air conditioner is $231. Similarly, DOE used the overall incremental markup to estimate changes in the customer price, given changes in the manufacturer price above the baseline price resulting from a standard to raise equipment efficiency. For example, if a standard increases the commercial air-conditioner manufacturer price by $100, DOE can multiply this by the weighted-average overall incremental markup to estimate that the customer price will increase $156.

Table 7.8.1   Overall Baseline Markups

Market Sector	New Construction			Replacement			Weighted-Average
	Small Mech.	Large Mech.	National Account	Small Mech.	Large Mech.	National Account	
Wholesale	1.36	1.36	1.69	1.36	1.36		
Mechanical Contractor	1.48	1.35		1.70	1.55	1.60	
General Contractor	1.24	1.24		NA	NA		
Sales Tax	1.07	1.07	1.07	1.07	1.07	1.07	
Overall	2.66	2.42	1.80	2.47	2.24	1.71	2.31

Table 7.8.2   Overall Incremental Markups

Market Sector	New Construction			Replacement			Weighted-Average
	Small Mech.	Large Mech.	National Account	Small Mech.	Large Mech.	National Account	
Wholesale	1.11	1.11	1.27	1.11	1.11		
Mechanical Contractor	1.26	1.18		1.37	1.29	1.24	
General Contractor	1.13	1.13		NA	NA		
Sales Tax	1.07	1.07	1.07	1.07	1.07	1.07	
Overall	1.68	1.59	1.35	1.63	1.53	1.32	1.56

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